Acceptability of COVID-19 Vaccination among Healthcare Workers in Sudan: A Cross Sectional Survey

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Abstract

Introduction: Following emergency approval of COVID-19 vaccines, several studies have investigated COVID-19 vaccine acceptance and hesitancy especially among healthcare workers (HCWs). Nevertheless, the acceptability of the COVID-19 vaccine by HCWs in Sudan remains unclear. This study aims to investigate the acceptability of the COVID-19 vaccine and its determinants among the HCWs.

Methods: A web-based cross sectional study design was used to study COVID-19 vaccine hesitancy and its associated determinants. The semi-structured questionnaire was distributed electronically, data collection took place from March-April 2021.

Results: A total of 576 HCWs have responded to the survey with mean age of 35 years. The majority were females (53.3%), Medical Doctors (55.4%), and located in the capital state; Khartoum (76.0%). The absolute refusal of COVID-19 vaccine was expressed by 16% of the respondents while 57% were willing to get vaccinated. Males were twice to four times more likely to accept the vaccine. Lower acceptability of COVID-19 vaccine was significantly associated with the nursing profession (OR= 0.35, 95% CI:0.15-0.82, $P<0.00$), increased perceived harm from the vaccine (OR= 0.11, 95% CI: 0.05-0.23, $P<0.00$), lack of confidence in the source of vaccine (OR= 0.16, 95% CI:0.08-0.31, $P=0.00$), organizations and government supervising COVID-19 vaccination process (OR=0.31, 95% CI:0.17-0.58 $P=0.00$).

Conclusion: This study highlights a moderate level of COVID-19 vaccine acceptability by the HCWs in Sudan. Effective communication of correct, regular, up-to-date evidence on the safety and effectiveness of vaccines is crucial to building trust in vaccines. Special consideration should be in place to address vaccine hesitancy among female HCWs and the nursing profession.

Introduction

The novel coronavirus that was first emerged in December 2019 and developed into a global pandemic of coronavirus disease 2019 (COVID-19) by March 2020 (1). Since then, the number of COVID-19 cases has been escalating and by 27th of June 2021, the global number of cases exceeded 179 million confirmed cases with 4 million confirmed deaths (2). The rapid transmission of the disease and the high risk to global health have pushed the governments to implement harsh restrictions and regulations to control the pandemic including social distancing and massive use of facemasks. Despite all the preventive measures, the pandemic still developing and claiming more lives worldwide particularly among the first responders, the Healthcare Workers (HCWs) (3).

First infections of COVID-19 in Sudan were detected among international travelers and returnees who arrived in the country between February and March 2020 (4). Soon later, Sudan has suffered from the widespread of infections and the local dramatic development of the pandemic in lack of adherence among the public community and noncompliance of the individuals to the prevention measures that were promoted by the Ministry of Health (5).

The first glimpse of hope for humanity rose up in December 2020 when the World Health Organization (WHO) has validated the use of the first COVID-19 vaccine for humans (6). By February 2021, seven vaccines were deployed globally, with priority being given to the most vulnerable groups, including mainly the HCWs (7). However, the successful deployment of all these different vaccines to reach the optimal coverage that provides community-wide protection was challenged globally by the vaccine hesitancy (8). The concept of vaccine hesitancy refers to the rejection of vaccination or delay in considering taking it despite the presence of vaccine (9). Unfortunately, vaccine hesitancy was documented even among HCWs worldwide (9–11). The vaccine hesitancy is of high risk when it spreads among the HCWs. Mainly because this group of professionals is generally perceived by the public communities as the most trusted source of information, awareness, and encouragement for vaccine intake among other professionals and the public. A recent study in Saudi Arabia showed that despite the efforts of the Ministry of Health (MoH) to spread the data on the safety and effectiveness of the COVID-19 vaccine, nearly 50% of the HCWs were reluctant to take the vaccine (12). Similarly in Congo and the United States, merely 72% and 56% of the HCWs were hesitant about taking a COVID-19 vaccine (13, 14). Nevertheless, a high acceptance rate among HCWs was reported in some countries, such as Greece, France, and China where the rates were 80 %, 76.9%, and 76.4%, respectively (15–17).

The Expanded Programme of Immunization (EPI) in Sudan faces a similar challenge about vaccinating the vulnerable groups, particularly HCWs, although the number of cases steadily increasing and now it, as of June 2021, exceeded 36 thousand with more nearly 3000 related deaths (2). On the 3rd of March, Sudan received the AstraZeneca vaccine through the COVAX alliance (18). There is a huge gap of information about the hesitancy and/or acceptability of the COVID-19 vaccine among the HCWs. Therefore, this study aimed to contribute to filling this gap by investigating the perception, awareness, and attitude of HCWs towards the intake of COVID-19 vaccine and determine the underpinning beliefs and assumptions.

Materials And Methods

Study Design and Sampling:

A cross-sectional online survey was conducted during the period of March- April 2021, the inclusion criteria were HCWs who were practicing in Sudan during the data collection period including dentists, medical laboratory technologists, nurses, physicians, Pharmacists, paramedic staff, and public health workers, who agreed to participate in the study and having access to internet connection to fill out the online questionnaire. This survey was designed and implemented by the Ministry of Health as part of the preparatory phase for launching the COVID-19 vaccination campaign in the country.

The total number of HCWs targeted for the vaccinations as estimated by the Federal Ministry of health is 400000 HCW. Assuming that 50% is the expected magnitude of vaccine acceptance, using alpha error of 0.05 and margin of error 5 %, the minimum required sample size was 564 HCWs. The sample size was calculated using EPI-info 7 software. Convenience sampling technique was used to recruit the

respondents, the questionnaire was distributed through professional social media platforms that were exclusive for Sudanese HCWs.

Survey Instrument:

A semi-structured questionnaire was adopted from previous studies (14, 19). The questionnaire was self-administered through a Google form and it has three major sections: (A) Background characteristics include demographic and professional information related to the knowledge and training about COVID-19 and its vaccine. (B) COVID-19 Vaccine acceptance measured with two questions: Would you take the COVID-19 vaccine when it is available (Yes, maybe, No)? and would you advise your family and friends to take the vaccine (Yes, maybe, No)? and (C) Health believes model which was used to explore the determinants for Covid-19 vaccinations acceptability. The model explored the following items: the perceived susceptibility measured by considering oneself at risk to get COVID-19 infection and the need to take the vaccine. Perceived severity was measured as the expected outcome if the subjects contracted COVID-19 infection. Perceived harm was measured by concerns related to the safety and side effects of the vaccine. The perceived benefit was measured as beliefs in the vaccine efficacy and effectiveness. Cues to action which was measured as whom subjects are intending to protect by taking the vaccine. Perceived barriers were focused on potential lack of confidence in the vaccine producers, government and organizations supervising the vaccination process. Additionally, the open-end broad question: Do you have any comment regarding COVID-19 vaccination in Sudan? was used to qualitatively explore HCWs different perspectives on vaccine acceptability and hesitancy.

Data analysis:

Data from the google sheet was cleaned and entered into IBM® SPSS® Statistics (version 25).

Descriptive analysis: This was performed in form of frequency tables was done for categorical variables. Means (M) and standard deviations (SD) were estimated for the continuous variables such as age and years of working experience. For the open-end broad question: Do you have any Comments regarding COVID-19 vaccination in Sudan? Answers were translated (if were in Arabic), coded, and common themes were identified.

Inferential analysis: Bivariate analysis and multivariable logistic regression analysis was performed to test for determinants of acceptance of COVID-19 vaccination. Only definitive Yes/No responses were included in this analysis excluding the “maybe” answers. Cross tabulation and Persons Chi-Square test was done to test associations between the outcome variables. Crude Odds Ratio (OR) was used as the estimate of the association. A P value < 0.05 was used as an indicator for the level of significance. These associations have been further adjusted using Multivariable logistic regression. Adjusted Odds Ratio (AOR), 95% CI for the AOR, and a significant level of $P < 0.05$ were used.

Ethical Considerations:

The survey was conducted by the Expanded Programme of Immunization (EPI), Federal Ministry of Health as part of the country's immediate response strategy for the COVID-19 pandemic including the preparation for vaccination throughout the country. Therefore, the need for ethical approval was waived by the National COVID-19 Response Committee. However, informed consent with study explanatory statements was shared with HCWs before their voluntary enrollment in this study. Only HCWs who read and sign this informed consent and provided their responses to the questionnaire were included in this study.

Results

Sociodemographic characteristics of respondents:

A total of 576 HCWs have participated in this study and responded to the survey. The demographic of the participants showed that females represented 53.3% (n = 307) and the mean age of the participants was 35 years old (SD = 10.6). The majority of the participants were working in Khartoum; the capital state of Sudan 438 (76.0%), and most of them were physicians 319 (55.4%) (Table 1). Regarding health characteristics, around 27% (n = 155) were diagnosed with medical comorbidity, mainly asthma (34.5%, n = 69), hypertension (24%, n = 48), and Diabetes mellites (20.5%, n = 41). Forty-five percent (n = 259) of the study participants have received training on COVID-19, yet only 24.5% (n = 123) and 8.7% (n = 50) have described their level of knowledge about COVID-19 disease and COVID-19 vaccination as “very good” or “excellent” respectively. Twenty percent (n = 115) had contracted COVID-19 infection before, and more than half (52.4%, n = 302) were directly or indirectly caring of COVID-19 cases (Table 1).

Table 1
Socio-Demographic and professional characteristics

Socio-Demographic and professional characteristics	Value	N = 576
Age (M $\pm$ SD)	35.3 (10.6)	
Gender	Male	269 (46.7%)
	Female	307 (53.3%)
Medical comorbidities	Yes	155 (26.9%)
	No	421 (73.1%)
Type of Medical Co-morbidities	Diabetes mellites	41 (20.5%)
	Hypertension	48 (24.0%)
	Asthma	69 (34.5%)
	Chronic Kidney Disease	5 (2.5%)
	Connective tissue Disease	5 (2.5%)
	Cancer	6 (3.0%)
	others	26 (13.0%)
Immune Suppressing Medications	Yes	15 (2.6%)
	No	556 (76.3%)
Health Profession	Medical Doctor	319 (55.4%)
	Nurses	17 (3.0%)
	Pharmacists	66 (11.5%)
	Medical laboratory Scientist	26 (4.5%)
	Public Health Workers	86 (14.9%)
	Dentists	26 (4.5%)
	Other(s)	36 (6.3%)
Years of practice or working experience (M $\pm$ SD)	10.4 (9.6)	

Socio-Demographic and professional characteristics	Value	N = 576
State of practice	Khartoum	438 (76.0%)
	Other than Khartoum	134 (23.3%)
	I don't work in Sudan	4 (0.7%)
Any training on COVID-19	Yes	259 (45.0%)
	No	317 (55.0%)
Knowledge about COVID-19	Excellent	141 (24.5%)
	Very good	221 (38.4%)
	Moderate	173 (30.0%)
	Good	29 (5.0%)
	Weak	12 (2.1%)
Knowledge about COVID-19 Vaccination	Excellent	50 (8.7%)
	Very good	123 (21.4%)
	Moderate	177 (30.7%)
	Good	118 (20.5%)
	Weak	108 (18.8%)
Diagnosed with COVID-19	Yes	115 (20.0%)
	No	461 (80.0%)
Family Members have ever been Diagnosed with COVID-19	Yes	216 (37.5%)
	No	360 (62.5%)
Directly or indirectly been taking care of the COVID-19 patients	Yes	302 (52.4%)

Socio-Demographic and professional characteristics	Value	N = 576
Would you take the COVID-19 Vaccine?	No	274 (47.6%)
	Yes	329 (57.0%)
	May be	155 (27.0%)
	No	92 (14.0%)
Advise friends and family to get vaccinated for COVID-19	Yes	438 (60.1%)
	May be	52 (7.1%)
	No	86 (11.8%)

Vaccine acceptability, hesitancy and refusal among HCWs in Sudan

A total of 329 (57.0%) HCWs expressed their willingness to be vaccinated against COVID-19, while 155 (27.0%) were hesitant, and only 92 (14.0%) were refusing to take the COVID-19 vaccine (Table 1). Furthermore, 438 (60.1%), 52 (7.1%), 86 (11.8%) have responded yes, maybe, and no, respectively, regarding advising friends and family to get vaccinated for COVID-19 (Table 1).

Parameters associated with acceptability of COVID-19 vaccine

Bivariate analysis (Table 2) showed that the mean age for those who would accept the vaccine was 36.5 years while the average age of refusers was 34.1 years, $P < 0.05$. The gender of the participant was found to be strongly associated with the acceptance rate with 85.8% of men accepting the vaccine compared to 70.5% among the female participants. Vaccine acceptance significantly increased with years of working experience (Difference in Means = 2.2, $P < 0.05$), receiving training related to COVID-19 vaccination, and taking care of COVID-19 patients directly or indirectly, $p < 0.05$. Those who rated their knowledge about the COVID-19 vaccination as excellent were significantly the least willing to be vaccinated (59.4%), $P < 0.05$.

Table 2

Bivariate analysis for Socio-demographic, profession, and health characteristics as determinants of COVID-19 vaccine acceptance

Characteristics	Value	Vaccine acceptance/refusal (N = 421 ¹) (%)		Unadjusted OR (95% CI)	p
		Accept (%)	Refuse (%)		
Age	Mean (sd)	36.5(11.5)	34.1(9.6)		0.04
Gender	Male	181(85.8)	30(14.2)	2.52(1.55–4.11)	0.00
	Female ²	148(70.5)	62(29.5)		
Medical Co-morbidities	Yes	93(79.5)	24(20.5)	1.11 (0.66–1.88)	0.68
	No ²	236(77.6)	68(22.4)		
Taking Immune suppressing medications	Yes	9(69.2)	4(30.8)	0.61 (0.18–2.06)	0.49
	No ²	316(78.4)	87(21.6)		
Health Profession	Medicine	190(79.2)	50(20.8)	1.03(0.93–1.14)	0.5
	Nursing	4(28.6)	10(71.4)	0.35(0.15–0.82)	0.00
	Pharmacy	31(72.1)	12(27.9)	0.91(0.75–1.10)	0.31
	Medical laboratory	13(76.5)	4(23.5)	0.97(0.74–1.27)	0.86
	Public Health	55(85.9)	9(14.1)	1.12(0.99–1.25)	0.1
	Dentistry	14(82.4)	3(17.6)	1.05(0.84–1.32)	0.66
	Other	22(84.6)	4(15.4)	1.08(0.91–1.29)	0.41
Years of practice	Mean (sd)	11.6(10.8)	9.4(8.6)		0.04
State where you are practicing	Khartoum State	245(76.3)	76(23.7)	0.629(0.34–1.14)	0.12
	Other than Khartoum State ²	82(83.7)	16(16.3)		
Any training on COVID-19	Yes	167(82.3)	36(17.7)	1.60(1.00–2.569)	0.04

Characteristics	Value	Vaccine acceptance/refusal (N = 421 ¹) (%)		Unadjusted OR (95% CI)	p
		Accept (%)	Refuse (%)		
	No ²	162(74.3)	56(25.7)		
Self-rated Knowledge about COVID-19	Weak	4(57.1)	3(42.9)	0.67(0.12–3.83)	0.65
	Good	14(66.7)	7(33.3)	0.57(0.12–2.70)	0.48
	Moderate	79(69.9)	34(30.1)	0.26(0.06–1.23)	0.09
	Very good	138(83.6)	27(16.4)	0.30(0.06–1.43)	0.13
	Excellent ²	94(81.7)	21(18.3)		
Self-rated Knowledge about COVID-19 Vaccination	Weak	38(59.4)	26(40.6)	0.50(0.25-1.00)	0.05
	Good	62(74.7)	21(25.3)	0.34(0.17–0.66)	0.00
	Moderate	103(81.1)	24(18.9)	0.28(0.14–0.59)	0.00
	Very good	83(83.8)	16(16.2)	0.17(0.06–0.49)	0.00
	Excellent ²	43(89.6)	5(10.4)		
History of COVID-19 infection	Yes	67(77.0)	20(23.0)	0.92(0.52–1.61)	0.77
	No ²	262(78.4)	72(21.6)		
Have Any of family members know been diagnosed with COVID-19?	Yes	120(78.4%)	33(21.6)	1.02 (0.63–1.66)	0.91
	No ²	209(78.0)	59(22.0)		
Have you directly or indirectly been taking care of the COVID-19 patients?	Yes	183(82.8)	38(17.2)	1.78 (1.11–2.84)	0.01
	No ²	146(73.0)	54(27.0)		
¹ respondents who answered” May Be” were excluded from the analysis.					
² reference category					

Table 2

Bivariate analysis for Health Believe Model as Determinants of COVID-19 vaccine acceptance or refusal among the 250 participants who responded yes/no excluding those who responded maybe.

Determinants	Question	Accept/Yes (%)	Refuse/No (%)	Unadjusted OR (95% CI)	P
Perceived susceptibility	I believe am at risk to get COVID-19 infection ¹	307(79.9)	77(20.1)	2.72(1.35–5.49)	0.00
Perceived benefit	I don't believe vaccine works	26(51.0)	25(49.0)	0.1(0.05–0.20)	0.00
Perceived harm (Over All) ²	High	13(34.2)	25(65.8)	0.11(0.05–0.23)	0.00
	Low	316(82.5)	67(17.5)		
Perceived barriers	I don't trust pharmaceutical companies making the vaccine ¹	37(42.0)	51(58.0)	0.16(0.08–0.31)	0.00
	I don't trust the agents / government overseeing COVID-19 vaccination process ¹	43(48.3)	46(51.7)	0.31(0.17–0.58)	0.00
Perceived severity	Mild	165(79.7)	42(20.3)	0.51(0.24–1.11)	0.09
	Moderate	69(88.5)	9(11.5)	0.52(0.19–1.39)	0.19
	severe	38(88.4)	5(11.6)	2.48(1.45–4.25)	0.00
	Not Concerned ³	57(61.3)	36(38.7)		
Cues to action	To prevent COVID-19 in myself	145(96.7)	5(3.3)	13.39(5.30–33.88)	0.00
	To prevent COVID-19 in friends and family Members	183(96.8)	6(3.2)	17.55(7.45–41.32)	0.00
	To prevent COVID-19 in community	208(95)	11(5)	12.35(6.32–24.11)	0.00
¹ reference =disagree					
² Perceived harm were described as “high” if the answer was “Agree” to all three items constructs, otherwise was described as “ low ”					
³ reference					

Also, Bivariate analysis (Table 3) showed a significant and positive association between HCWs vaccine acceptance and their perceived susceptibility to COVID-19 infection (OR = 2.72, 95% CI: 1.35–5.49, $P=$

0.00), perceived severity of the infection (OR = 2.48, 95%CI: 1.45–4.25, $P = 0.00$), and the perceived benefit from the vaccine. HCWs acceptance for the vaccine significantly reduced with increased perceived harm from the vaccine (OR = 0.11, 95%CI: 0.05–0.23, $P = 0.00$), lack of confidence in the vaccine producers (OR = 0.16, 95%CI:0.08–0.31, $P = 0.00$), the organizations and the government supervising COVID-19 vaccination process (OR = 0.31, 95%CI:0.17–0.58, $P = 0.00$) (Table 3).

Table 3

Bivariate analysis for Health Believe Model as Determinants of COVID-19 vaccine acceptance or refusal among the 250 participants who responded yes/no excluding those who responded maybe.

Determinants		Accept (%)	Refuse (%)	Unadjusted OR (95% CI)	P
Perceived susceptibility	I believe am at risk to get COVID-19 infection ¹	307(79.9)	77(20.1)	2.72(1.35–5.49)	0.00
Perceived benefit	I don't believe vaccine works	26(51.0)	25(49.0)	0.1(0.05–0.20)	0.00
Perceived harm (Over All) ²	High	13(34.2)	25(65.8)	0.11(0.05–0.23)	0.00
	Low	316(82.5)	67(17.5)		
Perceived barriers	I don't trust pharmaceutical companies producing the vaccine ¹	37(42.0)	51(58.0)	0.16(0.08–0.31)	0.00
	I don't trust the organizations / government supervising COVID-19 vaccination process	43(48.3)	46(51.7)	0.31(0.17–0.58)	0.00
Perceived severity	Mild	165(79.7)	42(20.3)	0.51(0.24–1.11)	0.09
	Moderate	69(88.5)	9(11.5)	0.52(0.19–1.39)	0.19
	severe	38(88.4)	5(11.6)	2.48(1.45–4.25)	0.00
	Not Concerned ³	57(61.3)	36(38.7)		
Cues to action	To prevent COVID-19 in myself	145(96.7)	5(3.3)	13.39(5.30–33.88)	0.00
	To prevent COVID-19 in friends and family Members	183(96.8)	6(3.2)	17.55(7.45–41.32)	0.00
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Table 3

Bivariate analysis for Socio-demographic, profession, and health characteristics as determinants of COVID-19 vaccine acceptance and/or refusal.

Characteristics	Value	Vaccine acceptance/refusal (N = 421 ¹) (%)		Unadjusted OR (95% CI)	p
		Accept (%)	Refuse (%)		
Age	Mean (sd)	36.5(11.5)	34.1(9.6)		0.04
Gender	Male	181(85.8)	30(14.2)	2.52(1.55–4.11)	0.00
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	Pharmacy	31(72.1)	12(27.9)	0.91(0.75–1.10)	0.31
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Years of practice	Mean (sd)	11.6(10.8)	9.4(8.6)		0.04
State where you are practicing	Khartoum State	245(76.3)	76(23.7)	0.629(0.34–1.14)	0.12
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Self-rated Knowledge about COVID-19 Vaccination	Weak	38(59.4)	26(40.6)	0.50(0.25-1.00)	0.05
	Good	62(74.7)	21(25.3)	0.34(0.17–0.66)	0.00
	Moderate	103(81.1)	24(18.9)	0.28(0.14–0.59)	0.00
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	No ²	146(73.0)	54(27.0)		
¹ respondents who answered” May Be” were excluded from the analysis.					
² reference category					

Determinant of COVID-19 vaccine acceptability among HCWs

Following bivariate analysis, the sociodemographic characteristics, professional characteristics and health belief model predictors were fitted with multiple logistic regression (Table 4). Only three sociodemographic and professional characteristics continued to be significant predictors for HCWs' vaccine acceptance namely: gender, the nursing profession, and self-rated knowledge about the vaccine. Males were twice more likely to take the vaccine compared to females (OR = 2.4, 95% CI: 1.23-4.63), $p < 0.01$). Nursing profession continued to be negative predictor for acceptance (OR = 0.04, 95%CI: 0.01–0.24, $P = 0.00$). In addition, self-rated knowledge about COVID-19 vaccination continued to be significantly and negatively associated with HCWs acceptance of the vaccine. Having a good (OR = 0.45, 95% CI: 0.08–2.46, $P = 0.01$), a moderate OR = 0.56, 95%CI:0.27–1.16, $P = 0.02$), and a very good OR = 0.36, 95%CI:0.19–0.81, $P = 0.02$).

Table 4
Multivariable logistic regression for Determinants of COVID-19 vaccine acceptance

Determinants of vaccine acceptance (Accept /Refuse)		aOR (95% CI aOR)	p
Age (M) (SD)		1.01(0.98– 1.05)	0.32
Years of practice (M) (SD)		0.99(0.92– 1.06)	0.66
Gender	Male	2.39(1.23– 4.63)	0.01
	Female ¹		
Health Profession	Medicine	0.25(0.08– 0.74)	0.01
	Nursing	0.04(0.01– 0.24)	0.00
	Pharmacy	0.22(0.05– 0.83)	0.03
	Medical laboratory	0.78(0.12– 4.94)	0.80
	Public Health	0.90(.25- 3.22)	0.10
	Dentistry	0.41(0.06– 2.80)	0.37
	others	0.45(0.08– 2.46)	0.36
Any training on COVID-19	Yes	1.32(0.58- 3.00)	0.51
	No ¹		
Self- rated Knowledge about COVID-19	Weak	1.02(0.28– 3.65)	0.98
	Good	0.91(0.27– 3.03)	0.87
	Moderate	0.68(0.17– 2.69)	0.58
	Very good	0.63(0.09– 4.03)	0.62
	Excellent ¹		
Self- rated Knowledge about COVID-19 Vaccination	Weak	0.41(0.06– 2.80)	0.12

Determinants of vaccine acceptance (Accept /Refuse)		aOR (95% CI aOR)	p
	Good	0.45(0.08– 2.46)	0.01
	Moderate	0.56(0.27– 1.16)	0.02
	Very good	0.36(0.19– 0.81)	0.02
	Excellent ¹		
Directly or indirectly been taking care of the COVID-19 patients	Yes	1.03(0.47– 2.35)	0.93
	No ¹		
Perceived susceptibility	yes	1.31(0.47– 3.63)	0.61
	No ¹		
Perceived Benefit		1.51(0.55– 4.14)	0.42
perceived barriers	I don't trust pharmaceutical companies making the vaccine ²	0.19(0.07– 0.47)	0.00
	I don't trust the organizations / government supervising COVID-19 vaccination process	0.59(0.25– 1.41)	0.24
Perceived harm	I don't believe the vaccine is safe	0.35(0.13– 0.96)	0.04
Perceived Severity	Mild	0.33(0.13– 0.86)	0.02
	Moderate	0.50(0.14– 1.82)	0.29
	high	1.65(0.76– 3.61)	0.21
Cues to action (taking the vaccine)	To prevent COVID-19 in myself 3	52.50(15.90- 172.60)	0.00
	To prevent COVID-19 in friends and family Members 3	85.09(27.30- 264.70)	0.00
	To prevent COVID-19 in community 3	54.55(20.89- 142.43)	0.00
¹ Reference category			
² Reference category = Disagree			

Among the Health Beliefs determinants, only perceived harm, perceived lack of confidence in vaccine producers, and all cues to take the vaccine continued to be statistically significant. Acceptability was significantly reduced with lack of confidence in the vaccine producers, OR = 0.19, 95%CI: 0.07–0.47, $P=0.00$) (Table 4). This was even higher than the significant negative impact of perceived harms from the vaccine (OR = 0.35, 95%CI: 0.13–0.96, $P=0.04$). The main cue to accepting the vaccine by HCWs was to protect their families (OR = 85.09, 95%CI: 27.30-264.70, $P=0.00$) (Table 4). A breakdown of the analysis for each variable can be found in Table 4.

Hcws' Concerns About Covid-19 Vaccination In Sudan

Besides the participants concerns about the safety and the possible side effects of the vaccine, some additional concerns about other aspects were expressed in the comments section of the questionnaire as follows:

A 37 years old male doctor. Stated "*I think there is a hidden agenda behind COVID-19 vaccine*", and a 35 years old female doctor was concerned about the effect of vaccine storing conditions on its safety and efficacy "*I am concerned about the storage of the vaccine*". Furthermore, two participants were worried about potential corruption related to vaccine distribution, which may lead to unequal distribution of the vaccine. Moreover, many participants emphasized the importance of information dissemination and increasing the awareness of the population to fight false rumors about the vaccine. Additionally, a female doctor suggested that all HCWs be tested for the COVID-19 IgG before vaccination. Lastly, a 39 years old female doctor stated that "For me, to be vaccinated or not is mainly dependent on the type of vaccine available. I do prefer the Oxford vaccine rather than the Pitfizer vaccine".

Discussion

The healthcare workers were among the most affected groups by the ongoing COVID-19 pandemic worldwide (20). Since its start in Sudan in March 2020, HCWs were burdened with COVID-19 mortality and morbidity (3, 4, 21). The current surge of COVID-19 cases leads to severe disruption of collateral health services (5, 22). Implementing preventive measures to protect HCWs was a real challenge, which was further complicated by the global shortage of Personal Protective Equipments (PPEs) (23). The rapid development of the COVID-19 vaccine has raised as one of the major strategies to reduce morbidity and mortality due to this pandemic (6, 24). Low- and middle-income countries (LMICs) including Sudan were challenged to strategically benefit from the vaccine to stop or at least to slow the current pandemic due to difficulties in achieving the optimal coverage among the most at-risk populations, mainly the front-line responders (25). Globally, efforts have been made for equitable access to the vaccine, with a main global understanding that "no one is safe until everyone is safe". Sudan has joined the COVAX AMC initiative in December 2020 and received 828,000 doses of the AstraZeneca vaccine through the initiative support (18), which is only enough to vaccinate less than 1% of the country population. Considering this limitation of vaccine supply, the national committee for COVID-19 deployment and vaccination plan has

prioritized the HCWs and most vulnerable groups (elders with co-morbidities) for the first phase of the vaccination to maintain the health service, reducing deaths and disease severity among the vulnerable group. Despite these efforts to make vaccines available for this key target group, vaccine acceptance by the HCWs would significantly affect its uptake. COVID-19 vaccination hesitancy has been of increasing concern in many countries (13, 14). In this survey, we measured the extent of acceptability of COVID-19 vaccination among HCWs in Sudan. We also identified key factors that could affect HCW's decision to take the vaccine. This is expected to support the development of evidence-based COVID-19 vaccination advocacy to ensure optimal acceptance of COVID-19 vaccine among HCWs in Sudan

The majority of respondents were young with average age of 35.3 years, direct or indirect caretakers of COVID-19's patients and 20% of them had a history of COVID-19 infection. Females represented more than half of the respondents and this matches the gender representation of the health workforce in Sudan. Sixteen percent expressed absolute refusal, which is double the percentage reported by HCWs in the US (14, 26). In contrast, 57% of the Sudanese HCWs will take the vaccine as soon as it is available. This relatively high acceptance rate is comparable to what has been reported by UNICEF in Ghana (27), and double the acceptance rate reported among Congolese HCWs (13). The latter has the lowest reported HCWs' vaccine acceptance globally (11). Nurses' likelihood to accept the vaccine was almost zero. They were the category of HCWs with the least acceptance rate for the vaccine.

To increase COVID-19 vaccine acceptance, positive reinforcement of public perceptions through effective communications of the correct and up-to-date evidence on the safety and effectiveness of the vaccines is crucial. Exposure to misinformation about the vaccine can lower COVID-19 acceptance by up to 6% (28). In this study, HCWs' acceptance was inversely correlated with their self-rated Knowledge about COVID-19 vaccination. It was clear that HCWs have built negative perceptions regarding the COVID-19 vaccine. This was translated into concerns regarding the process of development and safety of the vaccine, as more than half of the participants were worried about the vaccine's side effects. More than a quarter were worried about how rapidly the vaccine was developed. Perceived mistrust towards vaccine manufacturers and increased perceived harms from the vaccine reduced the vaccine acceptance by almost 80% and 65%, respectively. However, this is a global challenge given the fact that the vaccine for COVID-19 was developed within the shortest time in human history. This calls for putting extra effort to build public trust for the vaccine. The advocacy phase should focus on providing up-to-date information about vaccine safety. Implementation-wise, well-functioning adverse events and rumors tracking systems are vital.

Female HCWs were twice less likely to take the vaccine compared to their male colleagues. This might be explained by the gender disparities in perceived vaccine safety. Adverse events from COVID-19 vaccines have been unduly reported among Women compared to men, and it has been excessively covered in the news (29–31). The latter could have disproportionately built a negative perception of vaccine safety among females compared to males. It is crucial to take gender differences into account when addressing COVID-19 vaccine acceptance, as women represent the majority of the healthcare workforce in the country (26). This high hesitancy puts them at a higher risk of COVID-19 morbidity and mortality.

In conclusion, the acceptability of COVID-19 vaccination among HCWs in Sudan was average and comparable to others globally. Vaccine advocacy among HCWs needs to be aligned with the identified determinants. Acceptability was negatively determined by the female gender, the nursing profession, and knowledge about COVID-19 vaccination. Also, acceptability was significantly reduced by the increased perceived harm from the vaccine and the increased mistrust for the vaccine manufacture.

Strengths and Limitations: Little is known about the acceptability of COVID-19 vaccination among HCWs in LIMICs. The major strength of this study is that this survey is the first post vaccine availability survey to address determinants of COVID-19 vaccination acceptability among HCWs in Sudan. A potential limitation of this study is that the questionnaire was distributed in an online format which could introduce selection bias by excluding HCWs who do not have access to the internet.

Declarations

Conflict of interest: Authors have no conflict of interest to declare

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